

Deformation and Fracture at High Temperature

This research assists industry in the evaluation, design, and development of advanced structural ceramics for use as high-temperature components in land-based heat engines for power generation and vehicles, and in the development of measurement methodologies for the evaluation of the necessary high-temperature mechanical properties.

Ralph Krause, Jr. and William Luecke

We are studying the mechanisms and statistics of high temperature creep and rupture in advanced ceramics as well as developing and refining test methods for these measurements.

During 1998 and 1999 we conducted an international round robin for creep rupture of silicon nitride involving 14 laboratories, which comprise a large fraction of the possible laboratories. (Figure 1 shows the results) The analysis of that data is complete and submitted for publication. For $\log_e(\text{time-to-failure})$, the within- and between-laboratory coefficients of variation were 15% and 31% respectively. The corresponding coefficients of variation for creep rate, which is often the deformation parameter of interest, were 2.5% and 5.2%, respectively. During 2000 the data and the lessons learned were successfully incorporated into a precision statement for the relevant ASTM standard. The study showed that even reputable laboratories could differ significantly, which was unexpected from previous studies.

We are also characterizing the subcritical crack growth resistance of sapphire, under a program from the Office of Naval Research. Data are needed for lifetime and reliability prediction of windows for missile applications. Preliminary data, the first of its kind, indicate that sapphire has excellent resistance to subcritical crack extension.

We are actively collaborating with industrial as well as academic partners. With Chien-Wei Li of AlliedSignal (now Honeywell) we are characterizing the deformation of a next-generation silicon nitride. These data feed into our models for deformation and lifetime. With Michel Barsoum and his student Miladen Radovic we are characterizing the deformation and failure of a new class of machinable, ductile ceramics.

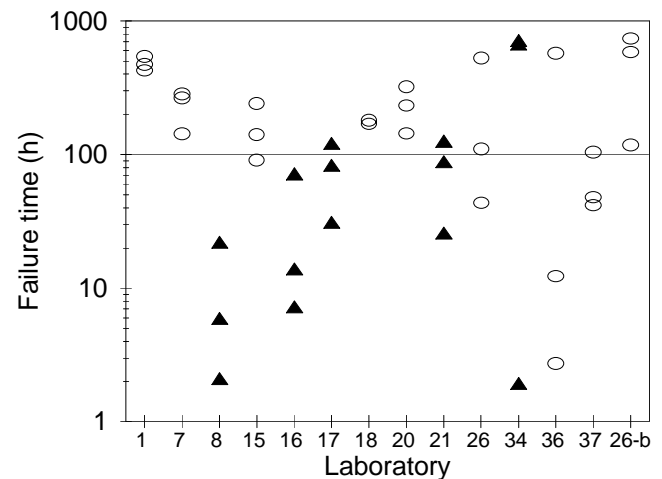
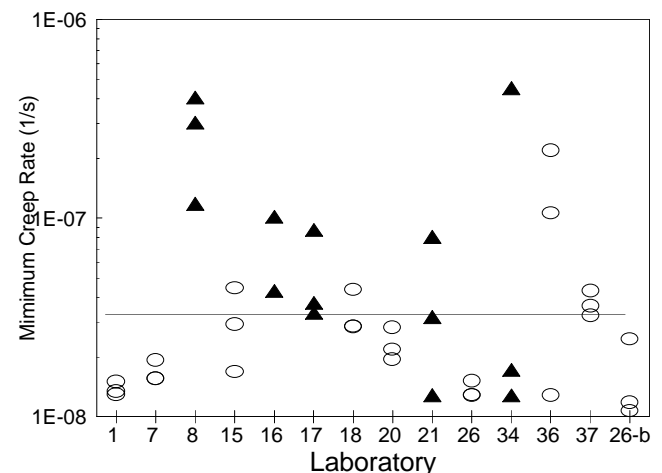


Figure 1. Results of an international round robin on creep rupture of silicon nitride. Solid symbols are from large specimens, open symbols are from small specimens. Solid lines are the grand mean of the data.



Contributors and Collaborators

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